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The Effect of Fermentation Technology on the Quality of Local Porang Flour

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Abstract. Porang (*Amorphophallus oncophyllus* Prain) is a promising food security crop in West Nusa Tenggara since it contains a lot of carbohydrates. However, the corm's high calcium oxalate level has made it difficult to use it in the food business. The objective of this study was to examine the influence of fermentation technology on calcium oxalate level and other porang flour properties. Fresh porang tubers from North Lombok were subjected to a spontaneous fermentation process for various durations of time, including 0, 12, 24, 36, 48, and 60 hours. The levels of oxalic acid, pH, total lactic acid bacteria, and the color of porang flour were all measured in this research. The findings of this study showed that fermentation of fresh porang tubers lowered the calcium oxalate content of flour and resulted in a brighter flour color when compared to unfermented corm flour. Although the oxalate concentration was slightly greater than the standard, the flour produced from the treatment fulfilled the quality requirements for porang flour. To increase the safety and quality of local porang flour, further research is required.

INTRODUCTION

Porang tuber (*Amorphophallus oncophyllus* Prain) is a tuber plant that thrives in the forest, mainly beneath permanent trees, on mountain slopes, or along rivers [1]. Porang tuber has a high economic value [2], and its market has significantly expanded in recent years. Many farmers have begun to plant porang in numerous Indonesian areas, notably West Nusa Tenggara province, due to the obvious potential market. Farmers, particularly those in marginal areas, need the Porang business as an alternative source of income and to enhance land productivity, which leads to a rise in the community income in the region.

Porang has high carbohydrate content, especially the glucomannan component [3]. When the corm is processed into flour, the glucomannan content can reach about 87% [4]. Glucomannan is a hydrocolloid polysaccharide consisting of D-glucose and D-mannose residues bound together in a bond of β-1,4 glycosides and β-1,6 glycosides [5]. With that characteristic, porang flour is a good source of carbohydrates for alternative food material and a potential food additive that can act as thickener, texture-forming, and thickener for food.

However, the high concentration of oxalate in porang corms has become a challenge in utilizing the corms as food materials. Oxalates are found in plants in two different types: water-soluble oxalates that bind to Na^+ and K^+, and

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insoluble oxalates that bind to divalent ions like Ca^{2+} and Mg^{2+} [6]. In acidic solutions, all types of oxalate dissolve [7]. In porang corm, oxalate is provided in the form of calcium oxalate, which is insoluble in water but dissolves readily in acidic solutions [8]. When ingested in high amounts, calcium oxalate may cause stinging, burning, and irritation of the skin, mouth, and digestive system. Kidney stones may be caused by a high oxalate intake. Furthermore, oxalate is an anti-nutritional compound that may prevent the body from absorbing nutrients like iron and calcium [9].

Porang corm has a high calcium oxalate content, which varies based on plant parts and harvest time [10]. The level of oxalate in the various types differs as well [11]. Previous research has shown that oxalate concentration in a variety of crops can be lowered. According to Kasaye *et al*. [12], heating and fermentation were effective methods for reducing the amount of oxalate in cassava and sweet potato flour. Another study found that fermenting breadfruit tubers for 72 hours may decrease the oxalate levels [13]. Kimchi's anaerobic fermentation process for five days lowered the average calcium oxalate concentration by 38.50%, as shown in a research on kimchi [6]. The physical, chemical, and functional characteristics of flour are altered by the fermentation process in tubers. These include texture changes in fermented flour or modified flour that is smoother than flour that has not been fermented [14]. Anggraeni and Yuwono [15] demonstrated that natural (spontaneous) fermentation may influence the physical features of sweet potatoes, such as a rise in color brightness and the eradication of the unpleasant fragrance in flour.

Fermentation periods may have an impact on flour quality. Wulandari, Hersoelistyorini, and Nurhidajah [16] reported that the finest grade gadung flour was achieved after 96 hours of fermentation. On the other hand, Widyasaputra and Yuwono [17] discovered that sweet potato flour with the finest physical qualities was fermented for 36 hours. There is currently a lack of research on the impact of the time of spontaneous fermentation on the quality of porang flour. This study describes the use of fermentation technology to decrease calcium oxalate in local porang flour and produce food-safe material.

METHOD

The experiment was conducted using an experimental method using a Completely Randomized Design (CRD) [18]. Fresh porang samples were obtained from local farmers in North Lombok Regency. The fermentation treatments and other stages of the trials were conducted with the same condition for all treatments in the Laboratory of Food Processing, Laboratory of Food Quality and the Laboratory of Food of Analytical Chemistry at the University of Mataram. There were six fermentation period or fermentation time treatments, including 0, 12, 24, 36, 48, and 60 hours. There were three replications for each treatment. The parameters analyzed in this trial were the total oxalate levels using the volumetric permanganatometric titration method [19], pH was analyzed using a pH meter [20], the total of lactic acid bacteria [21], and the color (L value) using a MiniScan EZ chromameter [22]. For the color assessment, the treated flour samples were placed on a neutral color plate, then the sensor lens of the colorimeter is placed directly over the samples to be measured. The average weight of the surface color (L value indicating the lightness level) of the samples was obtained by taking a triplicate of measurement. The Co-stat software was employed to examine the data collected from the observation using the Analysis of Variance at a 5% significant level. When there is a significant difference, the Honestly Significant Difference Test was used to confirm it at the same significant level [23].

RESULT AND DISCUSSION

This research indicated that the spontaneous fermentation time of the porang corm significantly reduced the oxalate content in porang flour. More results from this study are presented and discussed in the following sub-sections.

Result

The results obtained from this research indicated that spontaneous fermentation time significantly reduced the oxalic acid content (Figure 1) and the pH of porang flour (Table 1). On the other hand, the treatments increased the total lactic acid bacteria in porang flour (Table 1). Each of the parameters above will be described in more detail as followed.

The oxalic acid concentration was significantly affected by fermentation duration, as shown in Figure 1. As the fermentation period was extended, the amounts of oxalic acid reduced significantly. For 60 hours, the average oxalate content in porang flour from unfermented corm reduced from 5.26% to 1.9%. The corn fermented for at least 36 hours had a lower moderate oxalic acid level than the control or unfermented corm. Longer fermentation times (up to 60 hours) resulted in a considerable reduction in oxalic acid concentration. The coefficient determination (R^2) of the influence of fermentation time on oxalic acid reduction was 99%, according to the data in Figure 1.

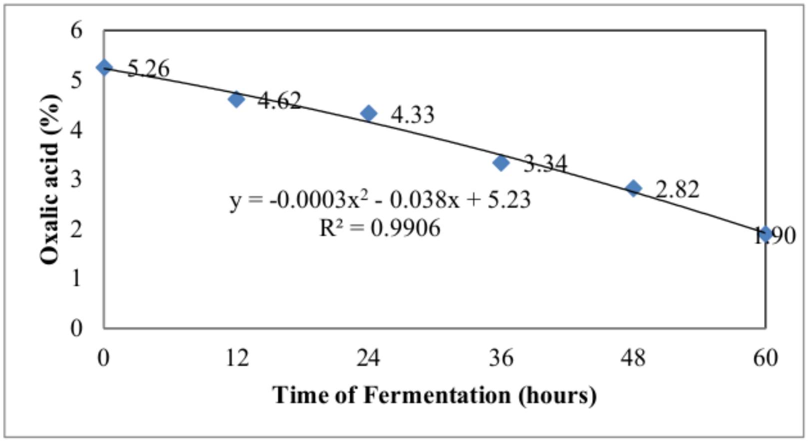

FIGURE 1. The regression on the effect of fermentation on the oxalic acid content of porang flour

Furthermore, the results also revealed that fermentation significantly reduced porang flour's pH (Table 1). In contrast, the treatments increased the total lactic acid bacteria and the L value (brightness value) of porang flour.

TABLE 1. The average pH, total Lactic acid Bacteria, and the color (L value) of porang flour during fermentation

Time of fermentation (hours)	pH	Total of LAB (CFU/g)	Color (L value)
0	7.05 a	1.00c	46.36
12	6.75 ab	3.46bc	67.33
24	6.48 bc	3.96 bc	69.09
36	6,75 ab	5.00 bc	72.72
48	6.45 bc	7.83 a	77.18
60	6.22 c	6.76 b	77.39
BNJ 5%	0.208	3.27	3.63

Note: Data followed by the same letters in the same column show no significant difference at the 5% significant level.

Discussion

Effect of Fermentation Time on the Oxalic Acid Levels of Porang Flour

Porang flour contains oxalate, which may be harmful to human health. Treatments that minimize the amount of oxalate in flour are critical. Figure 1 demonstrates how porang corm fermentation reduced the amount of oxalate in the flour. The calcium oxalate level of porang flour drops significantly as fermentation progresses. During the fermentation process, the starch granules may be leached and enzyme hydrolyzed, resulting in a decline in oxalate concentration. Furthermore, the activity of microorganisms during the fermentation process may cause significant cell damage, resulting in oxalate leakage in the corm and a reduction in calcium oxalate level in the flour. This is confirmed by the findings of Ojokoh, Daramola, and Oluoti [13], which discovered that fermenting breadfruit tubers for 72 hours lowered oxalate content. Other studies [24] also reported that after 48 hours of fermentation, the oxalate level of cocoyam flour (kimpul flour) dropped.

Although decreased significantly, the calcium oxalate content of porang flour in this study has not met the safe oxalate level requirements for food materials. Wardani and Handrianto [9] state that the calcium oxalate level in porang tubers for food materials is expected to be about 0.4-1.5%. The consumption limit of 0.6-1.25 grams per day if consumed for six consecutive weeks. Therefore, another alternative technology that is more effective to reduce oxalate content is needed to be developed.

Effect of Fermentation Time on pH Levels of Porang Flour

The pH value is the degree of acidity used to express the level of acidity or alkalinity of a substance, solution, or object [25]. The degree of acidity or pH level is one of the critical factors affected by microorganisms' growth. Subagio *et al.* [26] stated that a decrease in pH might occur because of the microbial growth during the fermentation process that can destroy the cell walls of the material. Then, it is followed by the degradation of the complex compounds and produces monosaccharide, which is further used as raw materials to create several types of organic acids. Several microorganisms are known to grow during porang fermentation. According to Rahmadi [27], lactic acid bacteria from the genus of Lactobacillus are naturally found in tubers. Corsetti and Settanni [28] also stated that Lactobacillus plays a vital role in tuber fermentation products in flavor development by producing several organic acids, improving nutrition, and having antimicrobial compounds. Also, Tope [29], [30] and Etsuyankpa [31] show that microorganisms from the yeast class such as *Saccharomyces cerevisiae* are known to grow on fermented beans and tubers (cassava and potatoes). Yeast can produce several organic acids, such as butyric acid, acetic acid, acetone, and acetaldehyde. Utama et al., [32] explained that these organic acids are made from the pyruvate biosynthesis process during fermentation. Nasrun *et al.* [33] also described that yeast cells produce organic acids such as malic acid, tartaric acid, acetic acid, citric acid, butyric acid, lactic acid propionic acid as side products. These organic acids then contribute to a decrease in the pH level.

The decrease in pH of porang flour during fermentation in this research, for example, the pH 7.05 of porang flour from unfermented corm to about 6.48 in the flour extracted from the corm fermented for 24 hours as indicated in Table 1. This may be associated with the activity of microorganisms (mainly lactic acid bacteria) that break down the carbohydrate components in the corm including the degradation of starch into glucose and produce some acids. The longer the fermentation, the higher the production of acid components in the corm, resulting in the lower pH value. Yuda *et al.* [34] reported that the longer the fermentation of kluwih seed with *Saccharomyces cerevisiae* reduced the flour from pH 4 to pH 3.5. This finding was also in line with the research by Gunawan *et al.* [35] that fermentation with S. *cerevisiae* may reduce the pH of modified cassava flour from 5.8 to 4.4. The decrease in pH value due to the starch component's enzymatic hydrolysis into glucose and the glucose is further degraded and resulted in organic acid production.

Effect of Fermentation Time on the Total of Lactic Acid Bacteria of Porang Flour

Lactic acid bacteria (LAB) are types of bacteria that play an essential role in fermentation processes, including food production [36]. Data in Table 1 shows that the total LAB increased significantly during fermentation, from 1.00 to 7.83 CFU / g after 48 hours' fermentation. This is in line with the research of Hartiwi, Handayani, and Ariyana [37], which showed that during 48 hours of fermentation of tapioca flour, the growth of lactic acid bacteria was recorded at 6.07 - 7.29 log CFU / gram. This shows that during 48 hours, there is a growth phase and decreases (early death phase) when entering the 60-hour fermentation. Table 1 also shows that the increase in the number of lactic acid bacteria's growth is in line with a significant decrease in the pH value.

The increase in the total LAB in the porang flour produced higher activity of microorganisms and their metabolic products, including the flour's organic acid components. Rahmawati *et al.* [38] stated that lactic acid bacteria dominated early fermentation during corn flour production. These bacteria have the function to break down the starch into glucose, which then can be used as nutrients for their growth. Lactic acid bacteria also use glucose in the metabolic processes and produce lactic acid. Corsetti and Settanni [28] also pointed out that LAB fermentation produces lactic acid, acetic acid, ethanol, and CO_2. Lactic acid bacterial cells can also have other acids such as malic acid, tartaric acid, citric acid, and butyric acid as by-products [39].

CONCLUSION

Based on the results, it can be concluded that fermentation time had significant effects on the oxalic acid content and the pH level. On the other hand, the treatments increased the total lactic acid bacteria and produced a lighter color (L value) of porang flour. Although the oxalic content decreased substantially as fermentation was prolonged to 60 hours, the oxalate level was still high and has not yet met the minimum level requirement of porang flour for safe consumption. Therefore, further research on other alternative technologies for reducing the oxalate levels in porang flour is needed.

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PAGE 1

PAGE 2

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PAGE 4

PAGE 5

PAGE 6

PAGE 7